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ABSTRACT

Contributions of rule, attribute, and complete learning to solution of low (conjunctive) and high (conditional) level concept attainment problems were assessed in 2 experiments. Direct learning and transfer of models was compared with vicarious learning and transfer of observers. Subjects in the latter condition observed yoked models solve the initial problem before solving the intrarule transfer task themselves. Conjunctive results were similar for models and observers with efficient solution occurring for both. However, much greater positive transfer was apparent for models than observers in the conditional task. The findings also provide a replication of earlier work in rule and attribute learning. (Author)

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Vicarious Transfer of Rule and Attribute Learning with Low and High Level Concepts [1]

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Concept rules appear to range in difficulty from simple affirmatives and conjunctives to conditional and biconditional concepts. It is apparent, however, that with repeated problems of the same rule type, a learning-to-learn effect occurs (Bourne, 1970; Di Vesta & Walls, 1969; Haygood & Bourne, 1965; Securro & Walls, 1971). This learning involves the nature of the connective by which the relationship between different elements in successive tasks is expressed. Once the general rule is acquired, the subject's task becomes one of attribute identification for each new problem. Thus, while early problems in the solution series suggest a hierarchy of concepts from conjunctives to conditionals, efficient solution through positive intrarule transfer is eventually achieved regardless of rule difficulty at the outset.

Other experiments have yielded evidence of positive interrule transfer effects (Bourne, 1970; Bourne & Guy, 1968). For example, Lee (1968) found pretraining on "lower-level" concepts facilitated transfer to a "higher-level" biconditional concept. The conditional rule has been found even more difficult to attain than the biconditional in several studies (see Giambra, 1970). When the attributes remain the same, interrule transfer is more efficient in shifts to complemental than to non-complemental rules for adults (Guy, 1969). Bourne (1970) proposes that a truth table problem solving strategy is acquired. Once the logic of the truth table is understood, a subject may make a category error on the first instance of any class in a new connective rule, but should make no errors thereafter. Such a generalized problem solving strategy applicable across the calculus of propositions suggests a structural, hierarchical model of concepts.

Bourne (1970) states:

> This suggests that in some sense S has learned not just the four primary rules (if he has learned them at all as specific individual cases,) but the full conceptual system of rules--the entire calculus. He knows how to solve problems based on any rule within the system. He has encountered and solved a series of problems exemplifying a small set of rules, and from that experience he has learned a more general conceptual system. Just as the objects are positive instances of class concept and class concepts are positive instances of a rule, the rules can be said to be positive instances of the system [Pp. 554-555].

When primary bidimensional rules are used, three stimulus classes are negative and one positive for the conjunctive, while the opposite is the case for the conditional. That is, the conjunctive (Red $\cap$ Square) is exemplified only by the TT or True-True stimulus class where both Red and Square are present; TF, FT, and FF are negative instances. However TT, FT, and FF are examples of the conditional (Red $\rightarrow$ Square), while TF is not. It is apparent that systematic combination of attributes to make a concept learning card deck yields more positive than negative instances of the conditional rule and more negative than positive instances of the conjunctive rule. Generally, negative instances are more difficult to use than positive (Hovland & Weiss, 1953). Bourne, (1967) however, suggests an interaction of negative and positive training series with rule complexity when rule learning (RL), in which the subject is given the attributes relevant to solution at the outset, and attribute identification (AI), in which the combining rule is given, are considered apart from complete learning (CL).

Experiments involving RL, AI, and CL have shown positive intrarule transfer effects in error reduction between first and second problems for children (Di Vesta & Walls, 1969) and adults (Haygood & Bourne, 1965). In

the latter study, CL was more difficult than AI which in turn generally produced more errors than RL. For the more difficult, high level, conditional CL, large positive transfer effects occurred from the first to second problem. The same was true to a lesser extent for AI and RL. However, with the lower level conjunctive task little positive transfer could occur since performance on the initial problem was efficient.

In the classroom students are often expected to acquire a concept through demonstrations, films, attribute naming by teacher and peers, or other vicarious processes. Although "higher order" forms of acquisition and generalized novel combination learning can be transmitted to observers through exposure to modeling cues, imitation theory predicts greater difficulty in modeling more complex behavioral sequences (Bandura, 1965). Bandura and Walters (1963) indicate that when concept attainment requires the use of complex strategies or rules by the model, the solution cues apprehended by the observer may not constitute a sufficient sample to permit both rule and attribute attainment. Consequently, no behavior change is forthcoming (Bandura, 1969). Vicarious acquisition of a simple marble arrangement concept has been demonstrated with the experimenter serving as a model (Rosenthal, Moore, Dorfman & Nelson, 1971). The model's verbalizations were found to be important for retention of a concept clustering task with children (Rosenthal, Alford, & Rasp, 1971).

The purpose of the experiments reported here was to examine the assumption that concepts requiring more complex combining rules are less easily learned vicariously than directly. While some positive transfer should occur in all conditions, models' performance with difficult concepts should yield the greatest transfer effect. These assumptions should hold, to a lesser extent, for rule and attribute learning separately.

Experiment I

In this experiment concept rules were used to correspond to assumptions concerning vicarious solution of low and high level concepts. It was expected that fewer errors should occur for models than observers in conditional transfer but not in conjunctive.

Method

Design.--The design consisted of two factors with two concept problems. There were two variations in the Learner condition. In one variation, subjects designated as models solved two concept problems involving the same rule but different attributes. In the other, subjects designated as observers solved only the second problem, after observing attainment of the initial concept. There were two levels of Concept difficulty (conjunctive and conditional) thus making a Learner x Concept x Problems design. The data were analyzed by a mixed analysis of variance in this and the subsequent experiment. The original and transfer repeated Problems constituted the within subjects factor, although subjects serving as observers during original learning were yoked to their respective models. That is, observers were assigned the same original learning scores as their models for computation of transfer effects.

Subjects.--A total of 40 volunteer subjects (20 males and 20 females) participated in this experiment. The subjects were students (age $\overline{X}$ = 29.3 years) enrolled in graduate educational psychology courses at West Virginia University. No subjects had participated in or had prior knowledge of such concept learning tasks. They were randomly paired into model-observer dyads; these pairs were assigned at random to one of the two Concept conditions.

Stimuli.--The stimulus materials were standard 3 in. x 3 in. cards from the Wisconsin Card Sorting Test. A 54 card deck was composed of two identical sets of 27 cards. The 27 cards were selected to represent three stimulus dimensions (color, shape, and number) with three attributes each (red, yellow, blue; circle, triangle, star; and 1,2,3 respectively). Each problem required attainment of a concept with two relevant attributes (Bourne, 1970). There was one irrelevant dimension in each problem. The relevant attributes used for original learning were red-circles. Thus, the conjunctive concept for original learning was--all patterns which are red and circles are examples ($R \cap C$). The conditional concept is expressed--if a pattern is red then it must be circle to be an example ($R \rightarrow C$; $[\bar{R} \cup C]$).

Procedure.--A randomly determined model and observer were paired for the first or original learning task and then individually tested in the transfer problem. The observer was seated to the model's left at a table; the experimenter was seated opposite the model. The observer was instructed, "You are an observer. Observe carefully what we do, and learn as much as you can. Do you understand? You will watch and learn as much as you can now so that you will be able to perform well on the test problem that follows."

The model was given standard reception learning instructions. The dimensions and attributes were described, and the model was told that only two attributes would be relevant and that the presence or absence of a particular attribute/s could be important. However, no emphasis was given to the fact that the order in which the attributes appeared within a rule (conditional) might be related to problem solution (Haygood & Bourne, 1965).

The model responded to each successive stimulus card by placing it face up in either the YES or NO square in front of him on the table. The

experimenter then provided feedback by saying "right" or "wrong" to indicate whether positive and negative instances of the concept were correctly sorted. A correction procedure required the model to shift incorrect sorts to the opposite pile. Subjects were allowed as much time to respond as they desired and instructions emphasized accuracy rather than speed.

Criterion of concept attainment was 27/27 correct responses in which at least one positive instance occurred. Initial shuffling of the deck was made with the restriction that a positive instance appeared as the first card (Giambra, 1970). If more than 54 cards were required to attain criterion, the deck was reshuffled throughly, again with the restriction noted. A maximum number of 192 cards was presented.

Following solution of the original problem by the model, the transfer phase was begun. During this phase, half of each group solved the transfer problem immediately following original learning. That is, the models and observers were counterbalanced so that half of the models were presented the transfer task immediately after attainment of the initial concept, and half waited outside the experimental room while the observer solved the transfer problem. There were, thus, immediate and short delay transfer conditions for both models and observers solving either conjunctive or conditional concepts. As in the complete learning condition reported by Haygood and Bourne (1965), subjects were instructed that the transfer task would involve two new attributes related in the same way as in the former problem, i.e., by the same rule.

<u>Results</u>

Performance was measured by trials to last error and the number of

errors. These means are reported as complete learning (CL) results in Table 1. Since these two measures provided essentially the same results, only analyses of errors to criterion are discussed here. In order to determine the possible influence of short delay and immediate transfer a 2 (model-observer) x 2 (conjunctive-conditional) x 2 (immediate-delay) analysis of variance of errors on the transfer task was computed. The immediate-delay factor was nonsignificant F (1,32) = 2.25, p > .05 indicating that this factor did not differentially effect concept solution. Since its interactions with Learner and Concept conditions were also nonsignificant (p >.05), this factor was eliminated from subsequent analyses.

Insert Table 1 about here

An overall mixed analysis of variance was performed, crossing Learners (observer - model) and Concepts (conjunctive - conditional) as between subjects factors with Problems (original - transfer) as a within subjects factor. This analysis yielded main effects due to Learners, F (1,36) = 4.17, p <.05, to Concepts F (1,36) = 57.97, p <.01, and to Problems, F (1,36) = 9.96, p <.01. In addition, the Concepts x Problems interaction was significant, F (1,36) = 4.30, p <.05. In Table 1 it may be noted that, while conjunctive concept performance did not change markedly from problem 1 to problem 2, conditional solution did so. Other interactions were nonsignificant, p >.05. The Newman-Keuls test of multiple comparisons was used to examine simple effects of transfer. Comparison of original and transfer means yielded significant positive transfer for models solving conditional concepts (p <.01). Although other transfer assessments were nonsignificant, (p >.05), as may be noted in Table 1, mean improvement occurred between

original and transfer tasks in all conditions.

A Learners x Concepts analysis of variance of errors in the transfer phase was computed to examine those data separately. The analysis yielded F (1,36) = 7.79, p <.01 for the effect due to Learners; F (1,36) = 13.38, p <.01 for the effect due to Concepts; and F (1,36) = 5.64, p <.05 for the interaction of Learners and Concepts. This interaction is depicted in Figure 1. Omega Squared analyses (Hays, 1963) yielded estimates of variance proportion accounted for, ω^2 = .108 for Learners, ω^2 = .197 for Concepts, and ω^2 =.073 for the interaction of these factors.

Insert Figure 1 about here

Experiment II

The purpose of this experiment was to examine separately the contributions of rule learning and attribute identification to vicarious and direct concept attainment. Selection of rules whose initial difficulties have been shown to differ was viewed as essential to such analysis. This varying complexity level should differentially effect the RL and AI performance of observers. That is, models should show more positive transfer than observers in both rule and attribute learning with the conditional concept, whereas no such difference should be evident for the conjunctive. Haygood and Bourne (1965) found little difference in difficulty between RL and AI across two successive problems involving the conditional rule.

Method

Design.--The overall design consisted of three factors with two successive concept problems. One factor was composed of two Learner conditions

(model and observer). The second factor was compromised of two Concept or connective types (conjunctive and conditional). The third consisted of two Information conditions. In one Information condition subjects were provided the relevant attributes but required to learn the relevant rule (RL). The opposite was true for attribute learning (AI) subjects. Each subject within this 2 x 2 x 2 format was tested on two problems involving the same rule but different attributes.

Subjects.--The 80 subjects (51 male and 29 female) were students from the same pool as those used in the previous experiment. They were assigned to treatments, N=10 in each condition, by reference to a table of random numbers. Subjects were yoked to their respective models for computation of transfer effects.

Procedure.--The same 54 card stimulus deck was used as in Experiment I. The procedures were also the same. The observer was instructed to watch and learn as much as he could while his model solved the initial bidimensional problem. Reception paradigm instructions stressing accuracy rather than speed were given to models. Subjects were told that each problem had two relevant and one irrelevant dimension.

AI subjects were instructed to, "...determine which of the nine attributes are the important two." To be certain that AI subjects understood their rule, the rule was printed on a card that remained with them throughout the tasks. This rule was thoroughly explained to the subject by the experimenter. Further, an analogy problem involving animals was constructed to illustrate the rule. AI subjects did not begin the experimental task until they had demonstrated understanding of either the conjunctive or conditional rule on the animal problem. Subjects in the RL condition were

given a card listing the two important attributes. The order of these attributes on the card was not that implied by a conditional rule for problem one but was for the transfer problem. RL subjects were instructed, "Your task is to figure out how these two attributes are important -- that is, how they are related."

As in the previous experiment, the second attainment problem was solved separately by models and observers. Subjects were told that the transfer task would use the same rule, and those in the RL condition were given a new attribute card (Haygood & Bourne, 1965). Subjects sorted the cards, with a correction procedure, to a criterion of 27/27 correct responses or a maximum of 192 trials.

Results.

Trials to last error and number of errors were recorded. These means for RL and AI are reported in Table 1. Again, only analyses of errors to criterion are discussed since these measures yielded similar findings. As in Experiment I, analysis of variance of transfer errors indicated no significant effect for the differential delay between first and second tasks, $F\,(1,64) = 0.15$, $p > .05$ in a Learners x Concepts x Information x Delay analysis; no significant interactions occurred.

An overall Learners x Concepts x Information x Problems mixed analysis of variance of errors yielded a significant effect due to Concepts, $F\,(1,72) = 86.8$, $p < .01$. Other main effects and interactions did not reach significance ($p > .05$). In Table 1, the reader may note that six of the eight transfer problem means (errors and trials) are lower for models than observers in AI and RL conditions. The more marked mean difference between models and observers appears in conditional transfer treatments where four of four means are higher for observers. In addition, more AI and RL means are in

a positive transfer direction for models than observers.

Analysis of variance of errors on the transfer task yielded F $(1,72) = 36.16$, $p < .01$ for Concepts; F $(1,72) = 2.59$, $p > .05$ for Learners; F $(1.72) = 1.01$, $p > .05$ for Information; and F $(1,72) = 1.98$, $p > .05$ for interaction of Learners and Concepts. Other interactions yielded $F < 1.0$. Omega squared computations indicated that the only factor accounting for an appreciable portion of the total variance was Concepts, $\omega^2 = .82$.

Discussion

The present studies investigated the effects of low and high level concept tasks on direct and vicarious transfer. Intrarule transfer was measured with two relevant and one irrelevant dimensions in complete learning, CL, rule learning, RL, and attribute identification, AI, paradigms.

The conjunctive problems were, as would be expected, more easily learned than conditionals. Initially, conjunctive CL was attained with only 7.5 mean errors, leaving little room for significant improvement. As expected, however, models and observers were equally efficient (means of 4.1 and 5.5 errors respectively) at conjunctive CL following a single problem exposure to that rule. Similarly, where subjects had only to discover a pair of relevant attributes (AI), few errors occurred. As in the Haygood and Bourne (1965) study mastery of conjunctive RL was achieved in one problem. These findings appear to hold whether prior experience is gained directly or vicariously.

Certain differences between the present studies and Haygood and Bourne should be noted. In that study, extra cards were inserted in the basic deck to provide "roughly equal" numbers of positive and negative instances; none were inserted in the present experiments. Accordingly, the criterion

of problem solution was increased from 16 to 27 consecutively correct category responses. As mentioned previously, however, the conjunctive rule is positive for only the TT stimulus class; TF is the only negative class for the conditional rule. Thus, for an unaltered stimulus deck as used herein, the majority of cards are negative instances of the conjunctive concept, but the deck contains predominantly positive instances of the conditional rule. This inequity should work to reduce the difference in performance on these two problem types (Hovland & Weiss, 1953), although this assumption has been questioned (Bruner, Goodnow & Austin, 1956; Hunt, 1962). Bourne (1967) suggests that a mixed deck should provide opportunity for more efficient conjunctive or conditional RL than when all training instances are negative or all positive. The mixed presentation also favors conditional AI; conjunctive AI is achieved most easily when the training series contains only positives and least well with all negatives.. Table 1, however, reveals findings for the latter condition particularly, and for other conditions generally, in agreement with Haygood & Bourne (1965).

As in other studies (Bourne, 1970; Di Vesta & Walls, 1969) substantial positive transfer was evident with the difficult task. Subjects in those experiments performed in roles similar to that of models in the present investigation. Less than one-third as many errors were made by models in transfer of the conditional CL as compared to original learning. Moreover, observers made three times as many errors as models in the conditional transfer task. Thus the expected Learners by Concepts interaction was obtained. Vicarious as compared to direct transfer has been shown to be less efficient in difficult tasks such as rote paired-associate learning (Simon & Ditrichs, 1968). Simon, Ditrichs, and Martin (1969) found model-

observer differences to be more pronounced in the A-B, A-B' paradigm than in the A-B, C-D warm-up or the A-B, A-C classical interference designs. The A-B, A-B' format is similar in some respects to repeated concept examples in which the rule remains the same and the attributes vary within the same dimensions (Di Vesta & Walls, 1967).

Bourne (1970) likens acquisition of the truth table strategy to "4:2 paired-associates tasks." Bandura and Walters (1963) suggest that acquisition of imitative responses result primarily from contiguity of sensory events. Learning of larger segments or entire behavior patterns rather than strengthening of stimulus-response sub-units typically occurs when a model is provided. However, when the model uses complex strategies or rules, sufficient solution cues may not be sampled by the observer. Solution may, indeed, be more difficult when the structural, hierarchical model of concepts (Bourne, 1970) is entered at the rule level than when prerequisites at the attribute level are provided to facilitate transition through exemplar and class levels to rule attainment.

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Footnotes

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[2] Request for reprints should be sent to Richard T. Walls, Educational Psychology, 806 F.T.A., West Virginia University, Morgantown, West Virginia.

Table 1

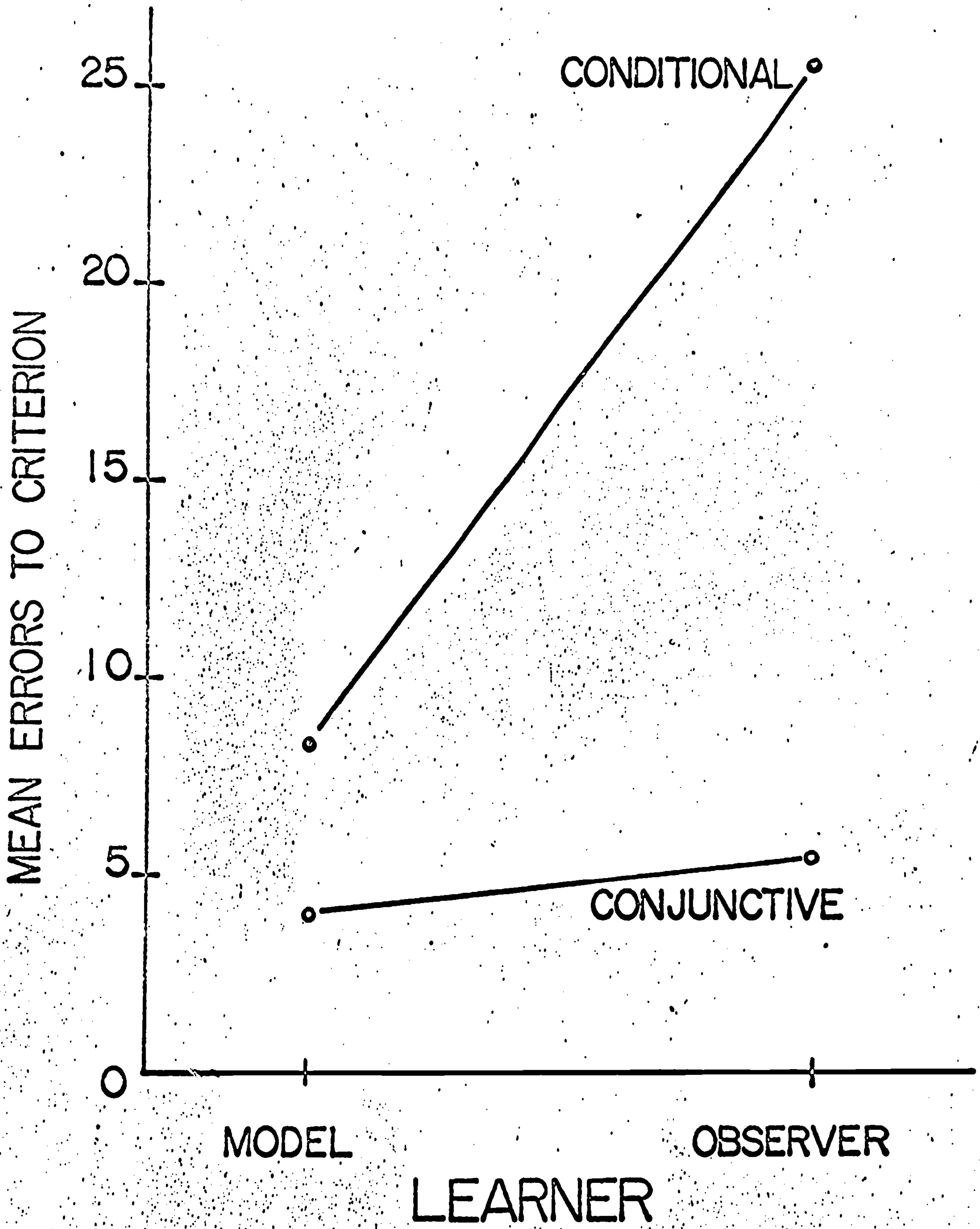
Mean Number of Errors (E) and Trials (T) to Last Error in Three Experiments

Rule	Instructional Condition	Problem 1 model E	Problem 1 model T	Problem 2 model E	Problem 2 model T	Problem 1 observer E	Problem 1 observer T	Problem 2 observer E	Problem 2 observer T	Experiment
Conjunctive	AI	3.0	14.2	2.5	16.6	3.0[a]	14.2[a]	3.8	18.9	Present Experiments
	RL	.9	4.3	.4	1.6	.9[a]	4.3[a]	.3	1.4	
	CL	7.5	27.7	4.1	21.5	7.5[a]	27.7[a]	5.5	27.4	
	AI	4.0	13.4	3.4	12.0					Haygood and Bourne (1965)
	RL	.2	.2	.4	.4					
	CL	3.6	14.0	3.0	6.4					
Conditional	AI	16.1	91.9	17.0	79.5	16.1[a]	91.9[a]	25.6	88.7	Present Experiments
	RL	22.1	81.3	13.4	51.3	22.1[a]	81.3[a]	22.8	91.1	
	CL	30.1	112.2	8.4	54.8	30.1[a]	112.2[a]	25.7	105.6	
	AI	26.8	49.4	12.2	47.8					Haygood and Bourne (1965)
	RL	16.4	57.5	10.4	45.8					
	CL	38.4	116.3	11.4	27.8					

[a] Observers were assigned the same scores as their models.

Figure Caption

Figure 1. Mean errors to criterion on the transfer problem as functions of Learners and Concepts in complete learning.


MEAN ERRORS TO CRITERION
25
20
15
10
5
0
CONDITIONAL
CONJUNCTIVE
MODEL
OBSERVER
LEARNER